

1 **I CLAIM:**

2 1. A thermally activated, chemically based marking
3 method comprising steps of:

4 electrostatically applying a layer of an energy
5 absorbing marking material to a conductive or
6 dielectric substrate to be marked; and
7 irradiating said layer with a radiant energy beam
8 having a wavelength selected to excite said
9 energy absorbing material in accordance with the
10 form of a marking to be applied, thereby forming
11 a marking layer atop said substrate.

12 2. The method of claim 1, further comprising a step of
13 providing a laminar air flow across said substrate during
14 the irradiating step.

15 3. The method of claim 1, wherein said marking
16 material comprises at least one metal compound.

17 4. The method of claim 3, wherein said metal compound
18 is an oxide.

19 5. The method of claim 4, wherein said compound is a
20 mixed metal oxide.

21 6. The method of claim 3, wherein said compound is a
22 sulfide.

23 7. The method of claim 3, wherein said compound is a
24 sulfate.

1 8. The method of claim 3, wherein said compound is a
2 carbonate.

3 9. The method of claim 1, wherein said marking
4 material comprises Kaolin clay.

5 10. The method of claim 1, wherein said marking
6 material comprises an energy absorbing enhancer.

7 11. The method of claim 1, wherein said marking
8 material comprises at least one colorant.

9 12. The method of claim 10 wherein said energy
10 absorbing enhancer comprises carbon black.

11 13. The method of claim 1, wherein said substrate
12 comprises materials selected from the group consisting of
13 metals, glasses, ceramics and plastics.

14 14. The method of claim 13, wherein said substrate
15 comprises at least one metal.

16 15. The method of claim 13, wherein said substrate
17 comprises at least one glass.

18 16. The method of claim 1, wherein said marking
19 material comprises at least one glass frit material.

20 17. The method of claim 16, wherein said glass frit
21 material comprises at least one oxide selected from oxides
22 of alkali metals, alkaline earth metals, silicon, boron and
23 transition metals.

1 18. The method of claim 1, wherein said marking
2 material comprises at least one glass frit material and at
3 least one metal compound.

4 19. The method of claim 11, wherein said marking
5 material comprises at least one organic pigment.

6 19. The method of claim 1, wherein said marking
7 material is applied by direct electrostatic coating of a
8 conductive substrate.

9 20. The method of claim 1, wherein said marking
10 material is applied by direct electrostatic coating of a
11 dielectric substrate, after said substrate has been coated
12 with a layer of conductive material.

13 21. The method of claim 1, wherein said marking
14 material is applied as dry particles.

15 22. The method of claim 1, wherein said marking
16 material is applied as liquid droplets.

17 23. The method of claim 1, wherein said marking
18 material is electrostatically applied in the form of a
19 marking to be applied to said substrate.

20 24. The method of claim 1 wherein said radiant energy
21 beam is produced by a laser, diode laser or diode-pumped
22 laser.

23 25. A substrate as marked by the method of claim 1.

24 26. A thermally activated, chemically based marking
25 method comprising steps of:

1 electrostatically applying a layer of mixed metal
2 oxide material containing an energy absorbing
3 enhancer to a metal substrate; and
4 irradiating said layer with a radiant energy beam
5 having a wavelength selected to excite the metal
6 oxide material and/or said energy absorbing
7 enhancer in accordance with the form of a
8 marking to be applied, thereby forming a marking
9 layer atop the substrate.

10 27. The method of claim 26 further comprising the step
11 of providing a laminar air flow across the substrate during
12 the irradiating step.

13 28. The method of claim 26, wherein the mixed metal
14 oxide material comprises at least one colorant, and the
15 energy absorbing enhancer comprises carbon black.

16 29. The method of claim 26, wherein the radiant energy
17 beam comprises a laser beam having an energy level ranging
18 between 1 and 30 watts, a spot size ranging between 5 and
19 200 microns, and a marking speed along the substrate ranging
20 between 25 and 1000mm/sec.

21 30. The method of claim 26, wherein the layer of mixed
22 metal oxide material has a thickness ranging between 5 and
23 500 microns.

24 31. The method of claim 26 wherein said irradiating
25 step is started at a room temperature of about 70° F.

1 32. A metal substrate as marked by the process
2 according to claim 26.

3 33. A thermally activated chemically based marking
4 method comprising steps of:

5 electrostatically applying a layer of mixed metal
6 oxide material containing an energy absorbing
7 enhancer to a substrate selected from the group
8 consisting of aluminum, brass, chrome, copper,
9 nickel, steel, stainless steel, tin, glass,
10 ceramics, porcelain, and plastics; and
11 irradiating said layer with a radiant energy beam
12 having a wavelength selected to excite the
13 energy absorbing enhancer in accordance with the
14 form of a marking to be applied, thereby forming
15 a marking layer atop the substrate.

16 34. The method of claim 33 further comprising the step
17 of providing a laminar air flow across the substrate during
18 the irradiating step.

19 35. The method of claim 33, wherein said mixed oxide
20 material is applied as dry particles.

21 36. The method of claim 33, wherein said mixed oxide
22 material is applied as liquid droplets.

23 37. The method of claim 33, wherein the energy
24 absorbing enhancer comprises carbon black.

1 38. The method of claim 33, wherein the radiant energy
2 beam comprises a laser beam having an energy level ranging
3 between 1 and 30 watts, a spot size ranging between 5 and
4 200 microns, and a marking speed along the substrate ranging
5 between 25 and 1000mm/sec.

6 39. The method of claim 33, wherein the layer of mixed
7 metal oxide material has a thickness ranging between 5 and
8 500 microns.

9 40. The method of claim 33 wherein said irradiating
10 step is started at a room temperature of about 70° F.

11 41. The method of claim 33, wherein the mixed metal
12 oxide material comprises a colorant.

13 42. A substrate material as laser marked by the process
14 according to claim 33.

15 43. A thermally activated, chemically based marking
16 method comprising steps of:

17 electrostatically applying a layer of mixed metal
18 oxide material containing an energy absorbing
19 enhancer to a substrate to be marked in the form
20 of a marking to be applied; and
21 irradiating said layer with a radiant energy beam
22 having a wavelength selected to excite the
23 energy absorbing enhancer, thereby forming a
24 marking layer atop the substrate.

1 44. The method of claim 43, further comprising the step
2 of providing a laminar air flow across the substrate during
3 the irradiating step.

4 45. The method of claim 43, wherein said mixed metal
5 oxide material is applied as dry particles.

6 46. The method of claim 43, wherein said mixed metal
7 oxide material is applied as liquid droplets.

8 47. The method of claim 43, wherein the energy
9 absorbing enhancer comprises carbon black.

10 48. The method of claim 43, wherein the radiant energy
11 beam comprises a laser beam having an energy level ranging
12 between 1 and 30 watts and a marking speed along the
13 substrate ranging between 25 and 1000mm/sec.

14 49. The method of claim 43, wherein the layer of metal
15 oxide material has a thickness ranging between 5 and 500
16 microns.

17 50. The method of claim 43, wherein the irradiating
18 step is started at a room temperature of about 70° F.

19 51. The method of claim 43, wherein the mixed metal
20 oxide material comprises a colorant.

21 52. A substrate material as marked by the process
22 according to claim 43.

23 53. A thermally activated chemically based marking
24 method comprising steps of:

electrostatically applying a layer having a metal oxide component and comprising an energy absorbing enhancing component to a metal substrate; and irradiating said layer with a radiant energy beam having a wavelength selected to excite the energy absorbing enhancing component, thereby forming an adhered marking layer atop the substrate.

54. A thermally activated, chemically based marking
method comprising steps of:

12 electrostatically applying a layer having a mixed
13 metal oxide component and an energy absorbing
14 enhancing component to a substrate selected from
15 the group consisting of aluminum, brass, chrome,
16 copper, nickel, steel, tin, glass, ceramics, and
17 plastics; and

18 irradiating said layer with a radiant energy beam
19 having a wavelength selected to excite the
20 energy absorbing enhancing component, thereby
21 forming an adhered marking layer atop the
22 substrate.

23 55. A thermally activated chemically based marking
24 method comprising steps of:

1 electrostatically applying a material containing at
2 least one metal oxide comprising an energy
3 absorbing enhancing component to a substrate to
4 be marked in the form of a marking to be
5 applied; and
6 irradiating said layer with a radiant energy beam
7 having a wavelength selected to excite the
8 energy absorbing enhancing component, thereby
9 forming a marking layer atop the substrate.

10 56. A thermally activated chemically based marking
11 method comprising steps of:

12 electrostatically applying a layer of a marking
13 material comprising at least one metal compound
14 to a markable substrate comprising at least one
15 material selected from the group consisting of
16 metals, glasses, ceramics and plastics; and
17 irradiating said layer with a radiant energy beam
18 having a wavelength selected to be absorbed by
19 said marking material, thereby forming a bonded
20 marking layer atop the substrate.

21 57. The method of claim 56, wherein said metal compound
22 comprises a metal oxide.

23 58. The method of claim 57, wherein said metal compound
24 is a mixed metal oxide.

1 59. The method of claim 56, wherein said metal compound
2 is a sulfide.

3 60. The method of claim 56, wherein said metal compound
4 is a sulfate.

5 61. The method of claim 56, wherein said metal compound
6 is a carbonate.

7 62. The method of claim 56, wherein said marking
8 material further comprises at least one energy absorbing
9 enhancing component.

10 63. The method of claim 56, wherein said marking
11 material comprises at least one colorant or pigment.

12 64. The method of claim 63, wherein said marking
13 material comprises at least one organic pigment.

14 65. A thermally activated chemically based marking
15 method comprising the steps of:

16 electrostatically applying a layer of glass frit
17 material containing an energy absorbing enhancer
18 to a glass substrate; and
19 irradiating said layer with a radiant energy beam
20 having a wavelength selected to excite the
21 energy absorbing enhancer in accordance with the
22 form of a marking to be applied, thereby forming
23 a bonded and permanent marking layer atop the
24 substrate which is visible in contrast with the
25 substrate; and

1 wherein the layer of glass frit material has a
2 thickness ranging between 5 and 500 microns.

3 66. The method of claim 65, further comprising the step
4 of providing a laminar air flow across the substrate during
5 the irradiating step.

6 67. The method of claim 65, wherein said glass frit
7 material is applied as dry particles.

8 68. The method of claim 65, wherein said glass frit
9 material is applied as liquid droplets.

10 69. The method of claim 65, wherein the glass frit
11 material further comprises a borosilicate glass and the
12 energy absorbing enhancer comprises carbon black.

13 70. The method of claim 65, wherein the radiant energy
14 beam comprises a laser beam having an energy level ranging
15 between 1 and 30 watts, a spot size ranging between 5 and
16 200 microns, and a marking speed along the substrate ranging
17 between 25 and 1000mm/sec.

18 71. The method of claim 65, wherein said irradiating
19 step is started at a room temperature of about 70° F.

20 72. The method of claim 65, wherein the glass frit
21 material further comprises a colorant.

22 73. The method of claim 72, wherein said colorant
23 comprises at least one organic pigment.

24 74. A glass material as marked by the process according
25 to claim 65.

1 75. A thermally activated chemically based marking
2 method comprising the steps of:

3 electrostatically applying a layer of glass frit
4 material containing an energy absorbing enhancer
5 to a metal substrate; and
6 irradiating said layer with a radiant energy beam
7 having a wavelength selected to excite the
8 energy absorbing enhancer in accordance with the
9 form of a marking to be applied, thereby forming
10 a bonded and permanent marking layer atop the
11 substrate which is visible in contrast with the
12 substrate; and
13 wherein the layer of glass frit material has a
14 thickness ranging between 5 and 500 microns.

15 76. The method of claim 75 further comprising the step
16 of providing a laminar air flow across the substrate during
17 the irradiating step.

18 77. The method of claim 75, wherein the glass frit
19 material comprises a borosilicate glass, and the energy
20 absorbing enhancer comprises carbon black.

21 78. The method of claim 75, wherein the radiant energy
22 beam comprises a laser having an energy level between 1 and
23 30 watts, a spot size ranging between 5 and 200 microns, and
24 a marking speed along the substrate ranging between 25 and
25 1000mm/sec.

1 79. The method of claim 75 wherein said irradiating
2 step is started at a room temperature of about 70° F.

3 80. The method of claim 75, wherein said glass frit
4 material is applied as dry particles.

5 81. The method of claim 75, wherein said glass frit
6 material is applied as liquid droplets.

7 82. The method of claim 75, wherein the glass frit
8 material further comprises a colorant.

9 83. A metal substrate as marked by the process
10 according to claim 75.

11 84. A thermally activated chemically based marking
12 method comprising the steps of:

13 electrostatically applying a layer of glass frit
14 material containing an energy absorbing enhancer
15 to a substrate selected from the group
16 consisting of glass, ceramic, porcelain,
17 aluminum, brass, steel, stainless steel and tin;
18 and

19 irradiating said layer with a beam having a
20 wavelength selected to excite the energy
21 absorbing enhancer in accordance with the form
22 of a marking to be applied, thereby forming a
23 bonded and permanent marking layer atop the
24 substrate which is visible in contrast with the
25 substrate.

1 85. A thermally activated, chemically based marking
2 method comprising the steps of:
3 electrostatically applying a layer of marking
4 material comprising at least one of a mixed
5 organic pigment material and an energy absorbing
6 enhancer to a plastic substrate; and
7 irradiating said layer with a radiant energy beam
8 having a wavelength selected to excite the
9 energy absorbing enhancer in accordance with the
10 form of a marking to be applied, thereby forming
11 a bonded and permanent marking layer atop the
12 substrate which is visible in contrast with the
13 substrate.

14 86. The method of claim 85, further comprising the step
15 of providing a laminar air flow across the substrate during
16 the irradiating step.

17 87. The method of claim 85, wherein said organic
18 pigment material comprises carbon black.

19 88. The method of claim 85, wherein the energy
20 absorbing enhancer comprises carbon black.

21 89. The method of claim 85, wherein the radiant energy
22 beam comprises a laser beam having an energy level ranging
23 between 1 and 30 watts, a spot size ranging between 5 and
24 200 microns, and a marking speed along the substrate ranging
25 between 25 and 1000mm/sec.

1 90. The method of claim 85, wherein the layer of mixed
2 organic pigment material has a thickness ranging between 5
3 and 500 microns.

4 91. The method of claim 85 wherein said irradiating
5 step is started at a room temperature of about 70° F.

6 92. The method of claim 85, wherein said organic
7 pigment material is applied as dry particles.

8 93. The method of claim 85, wherein said organic
9 pigment material is applied as liquid droplets.

10 94. A plastic substrate material as marked by the
11 process according to claim 85.

12 95. A thermally activated chemically based marking
13 method comprising the steps of:

14 electrostatically applying a layer of glass frit
15 material optionally containing an energy
16 absorbing enhancer to a substrate to be marked
17 in the form of a marking to be applied; and
18 irradiating said layer with a radiant energy beam
19 having a wavelength selected to excite the glass
20 frit material and/or said energy absorbing
21 enhancer, thereby forming a bonded and permanent
22 marking layer atop the substrate which is
23 visible in contrast with the substrate.

24 96. A thermally activated chemically based marking
25 method comprising the steps of:

1 electrostatically applying a layer of mixed metal
2 oxide material containing an energy absorbing
3 enhancer to a substrate to be marked in the form
4 of a marking to be applied; and
5 irradiating said layer with a radiant energy beam
6 having a wavelength selected to excite the
7 energy absorbing enhancer, thereby forming a
8 bonded and permanent marking layer atop the
9 substrate which is visible in contrast with the
10 substrate.

11 97. A thermally activated chemically based marking
12 method comprising the steps of:

13 electrostatically applying a layer of mixed organic
14 pigment material containing an energy absorbing
15 enhancer to a substrate to be marked in the form
16 of a marking to be applied; and
17 irradiating said layer with a radiant energy beam
18 having a wavelength selected to excite the
19 energy absorbing enhancer, thereby forming a
20 bonded and permanent marking layer atop the
21 substrate which is visible in contrast with the
22 substrate.

23 98. The method of claim 97, further comprising the step
24 of providing a laminar air flow across the substrate during
25 the irradiating step.

1 99. The method of claim 97, wherein the radiant energy
2 beam further comprises a laser beam having an energy level
3 ranging between 1 and 30 watts and a marking speed along the
4 substrate ranging between 25 and 1000mm/sec.

5 100. The method of claim 97, wherein said irradiating
6 step is started at a room temperature of about 70° F.

7 101. The method of claim 97, wherein said organic
8 pigment material is applied as dry particles.

9 102. The method of claim 97, wherein said organic
10 pigment material is applied as liquid droplets.

11 103. The method of claim 97, wherein the layer of mixed
12 organic pigment material has a thickness ranging between 5
13 and 500 microns.

14 104. A substrate as marked by the process according to
15 claim 97.

16 105. A thermally activated, chemically based marking
17 method comprising steps of:

18 electrostatically applying a layer of a marking
19 material comprising a Kaolin clay to a substrate
20 to be marked; and
21 irradiating said layer with a radiant energy beam
22 having a wavelength selected to excite at least
23 said Kaolin clay in accordance with the form of
24 a marking to be applied, thereby forming a
25 marking layer atop said substrate.

1 106. The method of claim 105, wherein said marking
2 material further comprises an energy absorbing enhancer.

3 107. The method of claim 105, wherein said marking
4 material is applied as dry particles.

5 108. The method of claim 105, wherein said marking
6 material is applied as liquid droplets.

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